

What is claimed is:

1. An optical switch that outputs optical signals input at any one of optical input ports from any one of optical output ports, comprising:

- 5        an input side switching element having a plurality of optical input ports and an output side switching element having a plurality of optical output ports;

         wherein said input side switching element is provided, at each of said optical input ports, with a group of input side  
10    deflection elements comprising a plurality of optical deflection elements arranged along the direction of incidence of the optical signals; and

         said output side switching element is provided at each of said optical output ports, with a group of output side optical  
15    deflection elements comprising a plurality of optical deflection elements arranged along the direction of emission of the optical signals.

2. The optical switch according to claim 1, wherein said input side and output side optical deflection element groups  
20    comprise, as said optical deflection elements, at least two moveable lenses of different focal point distance capable of movement within a plane perpendicular to the direction of incidence or direction of emission of said optical signals.

3. The optical switch according to claim 1, wherein said  
25    input side and output side optical deflection element groups comprise, as said optical deflection elements, moveable lenses capable of movement within a plane perpendicular to the

direction of incidence or direction of emission of said optical signals and moveable mirrors having axes of rotation perpendicular to the direction of incidence or direction of emission of said optical signals.

- 5           4. An optical switch that outputs optical signals input at any one of optical input ports from any one of optical output ports, comprising:

          a plurality of optical input ports and a plurality of optical output ports;

- 10           an input side optical deflection element provided at each of said optical input ports;

          an output side optical deflection element provided at each of said optical output ports; and

- 15           an input side optical fiber connected to said optical input port and an output side optical fiber connected to said optical output port; and

- wherein an optical system for expanding the optical input/output angle of said input side optical fiber and output side optical fiber respectively is provided at said optical  
20   input port and optical output port.

          5. The optical switch according to claim 4, wherein said optical system is a concave terminal face formed at the respective terminal faces of said input side optical fiber and output side optical fiber.

- 25           6. The optical switch according to claim 5, wherein said optical system is a concave terminal face formed at the

respective terminal faces of said input side optical fiber and output side optical fiber.

7. An optical switch that outputs optical signals input at any one of optical input ports from any one of optical

5 output ports, comprising:

a plurality of optical input ports and a plurality of optical output ports;

an input side optical deflection element provided at each of said optical input ports;

10 an output side optical deflection element provided at each of said optical output ports;

an input side optical fiber connected to said optical input port and an output side optical fiber connected to said optical output port; and

15 an optical system for expanding the beam diameter provided at said optical input port and optical output port.

8. The optical switch according to claim 7, wherein said optical system comprises a coupler coupled with each of terminal faces of said input side optical fiber and output  
20 side optical fiber and a plurality of lenses provided facing the terminal face of this coupler and arranged within a plane parallel with the terminal face of this coupler.

9. An optical switch that outputs optical signals input at any one of optical input ports from any one of optical

25 output ports, comprising:

a plurality of optical input ports and a plurality of optical output ports;

a moveable mirror having an axis of rotation perpendicular to the direction of incidence of the optical signal provided, as an input side optical deflection element, at each of said optical input ports; and

5 a moveable mirror having an axis of rotation perpendicular to the direction of emission of the optical signal provided, as an output side optical deflection element, at each of said optical output ports; and

US 6,771,911 B1  
10 wherein an optical element for focusing light reflected by said moveable mirror on the input side onto said moveable mirror on the output side is provided between said input side optical deflection element and output side optical deflection element.

15 10. The optical switch according to claim 9, wherein said optical elements are individually provided corresponding to the optical paths between said input side optical deflection elements and output side optical deflection elements.

20 11. An optical switch that outputs optical signals input at any one of optical input ports from any one of optical output ports, comprising:

an input side switching element having a plurality of optical input ports and an output side switching element having a plurality of optical output ports;

25 an optical element arranged between said input side switching element and said output side switching element; and

an optical element into which the optical signals from said input ports are incident as incoming beams and from which

emitted beams corresponding to these incoming beams are emitted such that the central optical paths of each ray bundle are mutually parallel.

12. The optical switch according to claim 11, wherein a  
5 convex lens is employed as said optical element and said input side switching element is arranged in the focal plane of said convex lens, said output side switching element and said input side switching element being arranged symmetrically on either side of and to the front and to the rear of said optical  
10 element.

13. The optical switch according to claim 11, wherein a  
hologram is employed as said optical element and said input side switching element is arranged in the focal plane of said  
15 hologram, said output side switching element and said input side switching element being arranged symmetrically on either side of and to the front and to the rear of said optical element.

14. The optical switch according to claim 11, wherein a  
20 concave mirror is employed as said optical element and said input side switching element is arranged in the focal plane of said concave mirror and said output side switching element is used in common with said input side switching element.

15. The optical switch according to claim 12, wherein  
said plurality of input ports are respectively provided with  
25 input side lens systems respectively corresponding to these input ports;

said plurality of output ports are respectively provided with output side lens systems respectively corresponding to these output ports; and

5 a concave lens is arranged at each plane where light is emitted from said input side lens system to said output side switching element and at each plane where light is incident from said input side switching element to said output side lens system.

10 16. The optical switch according to claim 15, wherein said input side lens system and said output side lens system respectively comprise a fixed lens or a moveable lens capable of movement in a plane perpendicular to the direction of incidence or direction of emission of said optical signal and a moveable mirror having an axis of rotation perpendicular to  
15 the direction of incidence or direction of emission of said optical signal.

17. The optical switch according to claim 16, wherein said input side lens system and said output side lens system respectively have a concave lens arranged between said fixed  
20 lens or said moveable lens and said moveable mirror.

18. The optical switch according to claim 12, wherein said convex lens comprises a first convex lens arranged individually corresponding to the optical path between said input side switching element and output side switching element  
25 and second convex lenses formed on either side of this first convex lens;

said plurality of input ports respectively having an input side lens system respectively corresponding to these input ports;

said plurality of output ports respectively having an output side lens system respectively corresponding to these output ports; and

said input side lens system and said output side lens system respectively comprising a fixed lens or moveable lens moveable in a plane perpendicular to the direction of incidence or direction of emission of said optical signal and a moveable mirror having an axis of rotation perpendicular to the direction of incidence or direction of emission of said optical signal.

19. The optical switch according to claim 13, wherein said plurality of input ports respectively comprise an input side lens system respectively corresponding to these input ports;

said plurality of output ports respectively comprise an output lens system respectively corresponding to these output ports; and

said input side lens system and said output side lens system respectively comprising a fixed lens or moveable lens moveable in a plane perpendicular to the direction of incidence or direction of emission of said optical signal and a moveable mirror having an axis of rotation perpendicular to the direction of incidence or direction of emission of said optical signal.

20. An optical switch that outputs optical signals from an input port side to an output port side, comprising:

input side switching elements having a plurality of input ports arranged in matrix fashion, and

5 output side switching elements having a plurality of output ports arranged in matrix fashion;

said input ports respectively having input side lens systems respectively corresponding to these input ports, and

10 said output ports respectively having output side lens systems respectively corresponding to these output ports;

15 wherein, of said input side and output side lens systems, at least the input side and output side lens systems at the periphery of said matrix arrangement are fixed or moveable lens systems operating so as to enable optical signals passing through the input side lens systems of this periphery to be guided to output side lens systems in the central part of said matrix arrangement.

21. The optical switch according to claim 20, wherein said input side lens system and said output side lens system  
20 respectively comprise at least two moveable lenses of different focal point distance capable of movement within a plane perpendicular to the input direction or output direction of said optical signal.

22. The optical switch according to claim 20, wherein  
25 said input side lens system and said output side lens system respectively comprise a fixed lens or moveable lens capable of movement in a plane perpendicular to the direction of



incidence or direction of emission of said optical signal and a moveable mirror having an axis of rotation perpendicular to the direction of incidence or direction of emission of said optical signal; and

5        optical elements to which the optical signals from said input ports are input as incoming beams and that focus the emitted beams corresponding to these incident beams are arranged between said input side switching elements and said output side switching elements.

10        23. The optical switch according to claim 22, wherein said optical elements are individually provided corresponding to the optical paths between said input side optical deflection elements and said output side optical deflection elements.

15        24. The optical switch according to claim 22, wherein plane mirrors are employed as said optical elements and said input side switching element is used in common with said output side switching element.

20        25. An optical switch that outputs optical signals input at any one of optical input ports and outputs these from one other of optical output ports, comprising:

an input side switching element having a plurality of optical input ports and an output side switching element having a plurality of optical output ports;

25        said input side switching element comprising first and second optical units;

said output side switching element comprising third and fourth optical units;

said first optical unit comprising a plurality of combinations of pairs of an input side light guide and incoming side lens system that focuses optical signals from this input side light guide, respectively corresponding to said optical input port;

said second optical unit comprising a plurality of first moveable mirrors arranged corresponding to said incoming side lens systems and that reflect optical signals from these incoming side lens systems;

said third optical unit comprising a plurality of second moveable mirrors that individually reflect optical signals from the moveable mirrors of said second optical unit; and

said fourth optical unit comprises a plurality of combinations of pairs of an emission side lens system that focuses the optical signals from said second moveable mirror and an output side light guide onto which optical signals are incident from this lens system, arranged respectively corresponding to said optical output ports.

26. The optical switch according to claim 25, wherein said first, second, third, and fourth optical units are provided on a common substrate.

27. The optical switch according to claim 25, wherein, within said first optical unit, said input side light guide is fixed on a first substrate and said incoming side lens system is fixed on a second substrate; and

wherein, within said fourth optical unit, said emission side lens system is fixed on a third substrate and said output side light guide is also fixed on a fourth substrate.

28. The optical switch according to claim 27, wherein  
5 said first to fourth substrates are substrates of the same thermal expansion coefficient.

29. The optical switch according to claim 26, wherein the thermal expansion coefficients of said first to fourth substrates and of said common substrate are the same.

30. The optical switch according to claim 27, wherein  
10 said first to fourth substrates are substrates having a small thermal expansion coefficient.

31. The optical switch according to claim 26, wherein  
15 said first to fourth substrates and said common substrate have a small thermal expansion coefficient.

32. An optical switch device comprising an optical switch having a moveable section for switching, a monitor section that monitors the emitted light from this optical switch, and an operation control section for adjusting the control  
20 condition of switching of said optical switch by controlling said moveable section for switching in response to a monitoring signal from said monitor section.

33. The optical switch device according to claim 32, wherein said moveable section for switching comprises optical  
25 signal introduction means that inputs an optical signal to said optical switch;

said monitor section comprises optical signal output means comprising an optical signal distribution section, and a monitor; and

5 said optical signal distribution section distributes and outputs said optical signal output from said optical switch to outside said monitor and this optical switch device.

34. The optical switch device according to claim 33, wherein said optical signal introduction means comprises a monitoring signal output source and a signal synthesizing  
10 section;

said signal synthesizing section inputs said input optical signal and monitoring signal output from said monitoring signal output source to said optical switch after converting these into a single synthesized signal; and

15 said optical signal distribution section comprises a filter that extracts only said optical signal from said synthesized signal output from said optical switch and outputs this to outside the optical switch device.

35. The optical switch device according to claim 34, wherein the operation of said monitoring signal output source is controlled by said operation control section.

36. The optical switch device according to claim 32, wherein said optical switch comprises a first optical switch and second optical switch;

25 said moveable section for switching comprises first optical signal introduction means and second optical signal introduction means mutually of the same construction for

inputting optical signals to said first optical switch and  
said second optical switch;

said monitor section comprises first optical signal  
output means and second optical signal output means mutually  
5 of the same construction;

said first and second optical signal output means  
respectively comprise an optical signal distribution section  
and a monitor; and

09307742, FILED  
10 said optical signal distribution section distributes and  
outputs and said optical signal output from said optical  
switch to outside said monitor and this optical switch device.

37. The optical switch device according to claim 36,  
wherein said first and second optical signal introduction  
means respectively comprise a monitoring signal output source  
15 and signal synthesizing section;

said signal synthesizing section inputs the monitoring  
signal that is output from said monitoring signal output  
source and said optical signal that is input to this optical  
switch device to said first and second optical switch after  
20 converting these into a single synthesized signal; and

said first and second optical signal output means  
comprises a filter that extracts only said optical signal from  
said synthesized signal output from said optical signal  
distribution section for outputting this to outside the  
25 optical switch device.

